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(71) Applicants
Sightworth Limited,
Monkgate House,
Monkgate,
York.
(72) Inventors
Peter Christian Shann
(74) Agents
Alan Tromans & Co.,
7, Seymour Road,
Finchley,
London, N3 2NG.

(54) Detonation of explosive charges

(57) A detonating device for detonating an explosive charge by energy from a laser comprises a length of optical fibre which terminates in a transverse end face and, adjacent to the end face, a body of a flashing composition of which the active material is selected from silver azide, the mono- and di-nitro resorcinols and their salts, and the mono- and di-nitroso resorcinols and their salts and mixtures of two or more of these active substances.

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SPECIFICATION

Detonation of explosive charges

The present invention relates to the detonation of explosive charges and has as an object the provision of improved arrangements for the detonation of explosive charges by laser energy.

By the present invention, there is provided a detonating device for detonating an explosive charge by energy from a laser, said device comprising a length of optical fibre which terminates in a transverse end face and, adjacent to the end face, a body of a flashing composition of which the active material is selected from the mono- and di-nitro resorcinols and their salts, and the mono- and di-nitroso resorcinols and their salts and mixtures of two or more of these active substances.

Flashing compositions are well known in the explosives art, eg. for coating the bridgewire used at the fusehead in electrical detonating systems. Connecting a set of fuseheads with an adequate source of electric power is a simple matter, the efficient jointing of the wiring to give the reqiured series or series-parallel circuit being readily accomplished in the field.

Unlike a wire used for the transmission of electrical energy, an optical fibre transmitting laser energy will deliver an output only in the direction of, and close to, its major axis. To be usefully employed the delivered energy must be intercepted, otherwise it is lost by transmission through the atmosphere which is a conducting medium for laser energy but an insulator for electrical purposes.

It is found that with a detonating device as provided by the present invention, the detonation of charges for a given amount of laser output energy is obtained in an especially reliable manner. The length of optical fibre may be connected with the laser via an optical channel having straight or branching connector arrangements (usually of the plug and socket type) whose performance would be unacceptable in conventional systems for the transmission of laser energy. The conventional systems have been developed mostly for communication purposes where low-loss fibres are essential and where branching connections are required to distribute the energy between the output fibres in precisely predictable proportions. Accordingly the invention permits the use of cheap non-precision components in the transmission channel with consequent economic advantages.

Examples of suitable components are described in the specification of co-pending patent application No.7913078.

Electrical detonation systems require precautions to prevent detonation by spurious currents, for example currents picked up from ground in the neighbourhood of electrical plant, currents produced by electric storm weather systems and radio frequency currents induced by radio transmissions. With a laser system using the present detonating device, the amount of energy which can reach the charges other than from the laser is well below that required for actuating the body of flashing composition.

In practice, the body of the flashing composition is preferably formed of the flashing material bound into a coherent form by the resinous binder, the most favoured binder being a nitrocellulose. Arrangements in which the body is in the form of a powder confined in a cell into which the fibre projects are possible.

One convenient arrangement is to provide the body in the form of a coating applied at least to the transverse end face of the fibre. Usually, and especially when the coating is produced by applying a mixture of the active material, a resinous binder and a volatile solvent, the coating extends over a region of the longitudinal (usually cylindrical) surface of the fibre contiguous with the end face. Dipping the end of the fibre into the mixture is the most convenient method of applying the mixture. By covering the coating with a lacquer, the coating is strengthened and protected for handling purposes and stabilised for storage.

In another arrangement, the end part of the length of optical fibre is fitted with a fibre locating component formed with a bore dimensioned to locate said end part, the fibre extending into the bore from one end thereof and the said body being exposed in the region of the other end thereof. With this arrangement, the body may be applied to the transverse end face after the fibre has been fitted to the fibre locating component. It may be located relative to the end face by the fibre locating component, eg. the fibre locating component may be provided with a recess into which the body is introduced in the form of a paste.

Blasting operations often involve the firing of a set of charges in a sequence rather than simultaneously. The timing of the firing of the individual charges to produce the sequence is usually produced by providing each charge, except perhaps the first to be fired, with an appropriate amount of a delay composition. It is within the scope of the invention to provide the fibre-locating component aforesaid with a channel which communicates with said body and is filled with a delay composition.

For most purposes, the device of the present invention, is conveniently provided as part of a fusehead assembly from which the length of fibre extends for connection with the laser system and which can be applied in detonating relationship with the charge to be fired as in electrical detonation. Especially with this arrangement, the body may be held by a body holder formed separately from the fibre locating component. In most practical cases, the fibre locating component is best provided in the form of a closure member, eg. a bung-type closure member for the fusehead. The body holder can then be inserted in the fusehead before the closure member is fitted.

The following description of preferred embodiments of the detonating device, in which description is made to the accompanying drawing, is given in order to illustrate the invention. In the drawing:

Figures 1 to *6* respectively show six different embodiments of the invention.

In the embodiment of Figure 1 a housing 1 in the

form of an aluminium tube is sealed at one end with a bung 2 of elastomeric material. An optical fibre 3 leading from a connector 4 for connecting it with a laser extends through bung 2 as shown into space 5. Typically, the optical fibre is a silica fibre of 0.2 mm diameter sheathed with a layer of silicone rubber and having an attenuation of 26 dB/km. Any external abrasion-resistant cladding is preferably a cheap cladding of the extruded type. Like the detonating device itself, the fibre is expendable.

Beyond space 5 is a tubular insert 6 filled with a conventional delay composition 7 followed, as in conventional practice, with a filling 8 of lead azide and a further filling 9 of pentaerithritol tetranitrate (PETN).

The end part of fibre 3 projecting into space 5 carries a coating 10 of mononitroresorcinol in the form of a lead salt bound by a nitrocellulose binder. This composition has been applied by dipping the end of the fibre, after insertion through bung 2, into a fluid mixture of the two components and acetone or other solvent for the binder, drying and coating with a cellulose lacquer.

A pulse of laser energy received along the fibre is absorbed by coating 10 where it covers the end face of the fibre. The lead salt ignites to form a flame of exothermically reacting matter which impinges on, and ignites the delay composition 7. Detonation of a charge to which the fusehead is applied is thereafter produced in a conventional manner.

The embodiment of Figure 2 is generally similar to that of Figure 1. However, instead of plug 2, the tube 1 is fitted with a bung 22 having a recess 23 formed in its end face. The end of fibre 3 extends into the recess where it is embedded in the subsequently applied body 10' of the lead salt and binder.

Figure 3 shows an embodiment for application where no delay composition 7 is required. In this case the bung 32 is long compared with bungs 2 and 22. The end part of recess 23' is filled with a small quantity of detonator for detonating the charge.

The embodiment of Figure 4 employs, instead of the bung 22 and the insert 6 of Figure 2, a combined component 42 in which the delay composition 7 is filled into a bore 43 which is contiguous with the entrance passageway for fibre 3.

In the embodiment of Figure 5, the fibre 3 (here shown with a silicone rubber coating 3') extends through bung 52 to project therefrom at 53. The flashing composition (dinitroresorcinol) 10" is provided separately in the form of a filling contained in the centre of an annular plug insert. With this arrangement of providing an insert containing the flashing composition as a separate component assembly of the fusehead is achieved more rapidly after cutting the fibre from stock than with the embodiments of Figures 1 to 4.

Insert 58 is an annular spacer which provides a gap between the flashing composition 10" and layer 8 of lead azide.

The embodiment of Figure 6 is a modification of that of Figure 5 in which a delay composition 7, held in an annular insert 6', is positioned between the insert 58 and the layer 8.

Used as a flashing composition as described herein, a nitro or nitroso- resorcinol can be activated with as little as 20 to 50 millijoules (mJ) of received laser energy. The sensitivity is of the same order as potassium chlorate, but potassium chlorate is much less stable under storage conditions. A laser giving an output of from 500 to 600 mJ per pulse, eg. a pulse of one millisecond, presents no design problems and with such a laser transmission losses in the fibres and at their connections are readily tolerated.

CLAIMS

1. A detonating device for detonating an explosive charge by energy from a laser, said device comprising a length of optical fibre which terminates in a transverse end face and, adjacent to the end face, a body of a flashing composition of which the active material is selected from silver azide, the mono- and di-nitro resorcinols and their salts, and the mono- and di-nitroso resorcinols and their salts and mixtures of two or more of these active substances.

2. A device according to Claim 1 in which the flashing composition is formed of the active material bound into a coherent form by a resinous binder.

3. A device according to Claim 2 in which the resinous binder is a nitrocellulose.

4. A device according to any one of Claims 1 to 3 in which the body of the flashing composition is a coating applied at least to the transverse end face.

5. A device according to Claim 4 in which the coating is covered with a lacquer.

6. A device according to any one of Claims 1 to 5 in which the end part of the length of optical fibre is fitted with a fibre locating component formed with a bore dimensioned to locate said end part, the fibre extending into the bore from one end thereof and the said body being exposed in the region of the other end thereof.

7. A device according to Claim 6 in which the said body is located relative to the end face by the fibre locating component.

8. A device according to either of Claims 6 or 7 in which the fibre locating component is formed with a channel which communicates with said body and is filled with a delay composition.

9. A device according to Claim 6 in which said body is held by a body holder formed separately from the fibre locating component.

10. A device according to any one of Claims 6 to 9 in which the fibre locating component is provided in the form of a closure member for a detonator.

11. A detonating device for detonating an explosive charge by energy from a laser, substantially as hereinbefore described and illustrated by reference to the accompanying drawings.

12. A method of producing a device according to either of Claims 2 or 3 in which the coating is produced by applying a mixture of the active material, the resinous binder and a volatile solvent for the resinous binder, to at least the end face of the fibre.

13. A method according to Claim 12 in which the mixture is applied by dipping the end of the fibre therein.

14. A method of producing a detonating device according to Claim 1, substantially as hereinbefore described and illustrated by reference to the accompanying drawings.

15. A detonating device when produced by a method in accordance with any one of Claims 12 to 14.

16. A detonating device according to any one of Claims 1 to 11 or Claim 15 in operative association with a laser.

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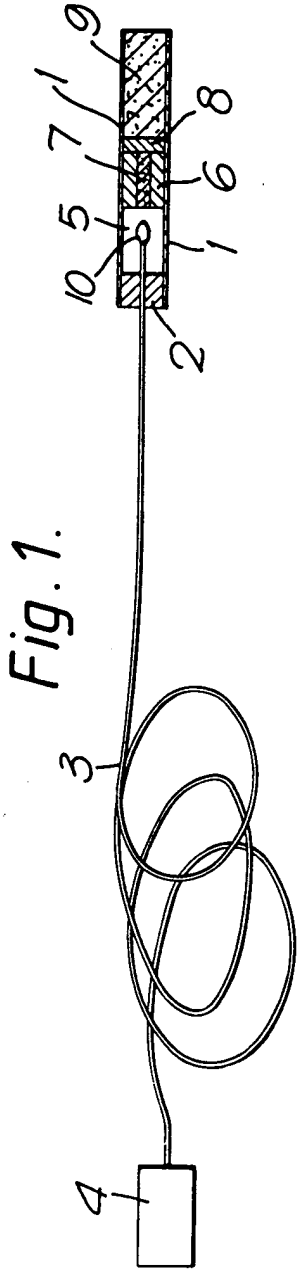

Fig. 1.

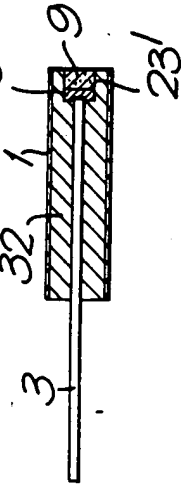

Fig. 3.

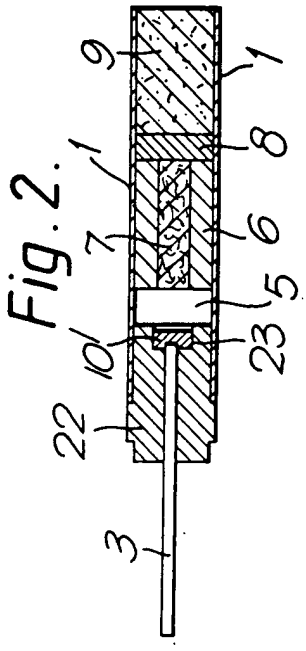

Fig. 2.

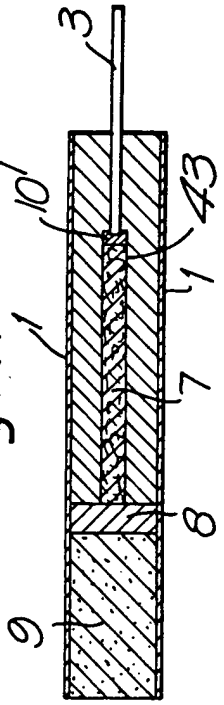

Fig. 4.

Fig. 5.

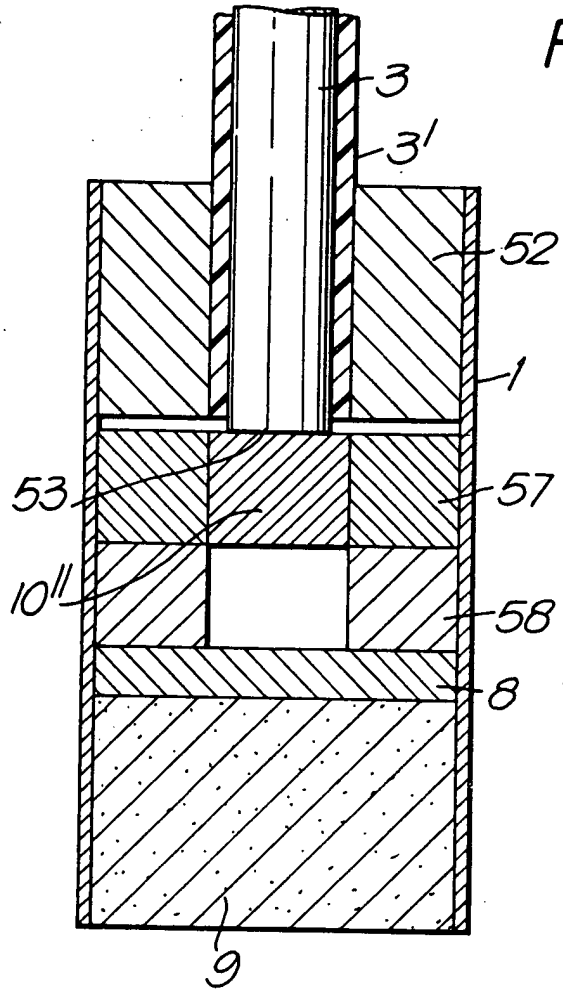

Fig. 6.